REMARKS

Claims 1-62 are pending in the Application prior to the amendments herein.

Claims 18-62 are withdrawn from consideration and cancelled without prejudice.

Claims 1-17 are rejected.

Claim 1 is amended herein to insert a limitation from claim 2 and to change "proton electrolyte membrane fuel cell electrode" in the preamble to "fuel cell electrode." Support for the amendments is in original claim 2 and at page 15, lines 11-20.

Claim 2 is cancelled herein.

Claims 1 and 3-17 are pending after entry of the amendments herein.

1. Restriction Under 35 U.S.C. § 121

The Examiner has restricted Claims into six groups. Applicant hereby confirms the election, without traverse, of Claims 1-17 belonging to Group I. Claims 18-62 are withdrawn from consideration and cancelled without prejudice.

2. Rejections Under 35 U.S.C. § 102(b)/ §103(a) over Marchetti

The Examiner has rejected Claims 1, 2 and 5, 12 and 17 under 35 U.S.C. § 102(b) as being anticipated by or, in the alternative, under 35 U.S.C. § 103(a) as obvious over Marchetti et al., U.S. Patent 5,277,996 ("*Marchetti*"). Office Action at 2.

Applicant respectfully traverses the rejection.

Anticipation requires each and every element of the claim to be found within the cited prior art reference. To establish a *prima facie* case of obviousness, at least three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify

the reference. Second, there must be a reasonable expectation of success. Finally, the prior art reference or references must teach or suggest all the claim limitations.

The Examiner contends that "*Marchetti* et al. discloses a fuel cell electrode and the method of producing the electrode. The electrode is constructed of a carbon material or layer known as fullerene (col. 5, lines 8-15)." Office Action at 2.

Marchetti teaches and suggests the use of $C_{60,}$ which is also the definition of a buckyball or fullerene, as cited below in *Marchetti*.

> This new carbon molecule contains 60 carbon atoms arranged roughly in a soccer ball shape, prompting the name "buckminster fullerene", "buckyball" or "fullerene."
>
> (See *Marchetti* at Col. 2, *ll.* 14-17.)

> The fullerene carbon layer 36, one of the principle aspects of the present invention, is located on the substrate layer 30. Layer 36 is composed of C_{60} carbon molecules which have roughly spherical or soccer ball shapes and are commonly known as "buckyballs" or "fullerenes."
>
> (See *Marchetti* at Col. 5, *ll.* 8-13.)

Applicant has amended Claim 1 to require, *inter alia*, that the carbon nanotubes comprise single-wall carbon nanotubes. Claim 2 has been cancelled and, therefore, rejection of this claim is now moot. Although carbon nanotubes and C_{60} are both composed of carbon, C_{60}, or buckyballs, have very different physical properties, morphology and chemical reactivity than those of single-wall carbon nanotubes. Buckyballs are round in shape and, because of the highly strained carbon bonds, have higher chemical reactivity. Buckyballs are also easily dispersed and purified. In contrast, single-wall carbon nanotubes (SWNT) are generally long and flexible with high aspect ratios (length-to-width ratios). The chemical reactivity and physical properties are very different than those of buckyballs. Furthermore, single-wall carbon nanotubes are also known to "stick" or aggregate together in "ropes." Once the single-wall carbon nanotubes are in

close proximity or touch, van der Waals forces strongly hold the nanotubes together. The van der Waals forces not only hold the single-wall carbon nanotubes in "ropes," but also hold them in place wherever they touch. Since single-wall carbon nanotubes are flexible, they often look like a "bowl of spaghetti" and due to the van der Waals forces, this tangled arrangement is difficult to untangle. Thus, because single-wall carbon nanotubes are held together in ropes and tangled masses, they are very difficult to separate, manipulate, disperse or handle individually.

Furthermore, the reactivity of single-wall carbon nanotubes is much different than buckyballs. Buckyballs have 60 carbon atoms bonded in hexagons and pentagons in a "soccer ball" arrangement. The carbon bonds are all highly strained, which makes bond breaking and functionalization proceed relatively easily. In contrast, single-wall carbon nanotubes are much more difficult to functionalize. First of all, the diameter of a single-wall carbon nanotube can vary between about 0.5 nm and about 3 nm. As the nanotubes become larger, the angle of curvature, and hence the reactivity of the nanotube, decreases. Furthermore, the sidewall of a single-wall carbon nanotube is generally defect-free, meaning that it resembles a seamless sheet of graphene on the sides. In order to functionalize single-wall carbon nanotubes, it is first necessary to disperse them, which is extremely difficult. After that, the functionalization must be done in a manner as to retain the nanotube structure. Thus, the functionalization of single-wall carbon nanotubes is neither trivial nor straightforward.

Furthermore, Claim 1 requires, *inter alia*:

> …a plurality of carbon nanotubes, wherein the plurality forms a mat of carbon nanotubes, wherein the mat has a planar area and wherein the mat has a thickness greater than one micron….

In contrast to the requirement of the present invention that the mat has a thickness greater than one micron, *Marchetti* teaches a carbon layer having a thickness much less than one micron,

more specifically, 200 Angstroms, which is equivalent to 0.02 microns or $1/50^{th}$ of a micron. Although *Marchetti* does teach different thicknesses of the fullerene carbon layer, *Marchetti* teaches that the layer is "only several molecule diameters thick, permitting rapid diffusion of hydrogen molecules..." (See *Marchetti* at Col 5, *ll.* 38-40.) Thus, *Marchetti* actually ***teaches away*** from thicker mats, especially one that would be over 50 times thicker, such as required by Claim 1.

Because of the numerous and significant differences between C_{60} and single-wall carbon nanotubes, as well as the extensive difficulties in manipulating single-wall carbon nanotubes and the much greater thickness of the mat in the instant invention, one of ordinary skill in the art would not be motivated to modify the teachings of *Marchetti* to achieve the elements claimed in Claim 1, as amended. *Marchetti* does not teach, suggest or provide motivation either for single-wall carbon nanotubes or for a carbon layer greater than one micron. Therefore, *Marchetti* does not teach or suggest all the claim limitations. Furthermore, there is no teaching or motivation provided by *Marchetti*, or in the knowledge generally available to one of ordinary skill, to modify the reference to arrive at the invention claimed in Claim 1, as amended. Furthermore, *Marchetti* teaches that the "fullerene carbon nanotube layer ... [is] **one of the principle aspects** of the ... invention." (Emphasis added, see *Marchetti* at Col. 5, *ll.* 8-9). This teaching clearly ***teaches away*** from modifying the carbon material. Thus, Claim 1, as amended, is not anticipated by *Marchetti* and a *prima facie* case of obviousness has not been established.

Claims 5, 12 and 17 are directly or indirectly dependent upon amended Claim 1, and are not anticipated by nor obvious over *Marchetti* for the same reasons that amended Claim 1 is not anticipated by nor obvious over *Marchetti*.

The Examiner stated that Claims 12 and 17 merely recite statements of intended use which were given no patentable weight. Applicant respectfully points out that this is not correct. Claim 12 states that the electrode is a component in a hydrogen/oxygen proton exchange membrane fuel cell (PEMFC), and Claim 17 states that the electrode is a component in a direct methanol fuel cell (DMFC). Both of these are specific structural limitations, i.e., that the electrode is part of a larger apparatus which is explicitly recited in the claims. These cannot be construed as mere statements of intended use (e.g., "The electrode of Claim 1, for use in [other apparatus]"). Therefore, the limitations of Claims 12 and 17 cannot be ignored when assessing patentability.

Therefore, in light of the foregoing, Applicant respectfully requests that the Examiner withdraw the rejection of Claims 1, 5, 12 and 17 under 35 U.S.C. § 102(b) as anticipated by or, in the alternative, under 35 U.S.C. § 103(a) as obvious over *Marchetti*.

3. Rejections Under 35 U.S.C. §103(a) over Marchetti in view of Fisher

The Examiner has rejected Claims 3 and 4 under 35 U.S.C. § 103(a) as being unpatentable under 35 U.S.C. § 103(a) over *Marchetti* as applied above, and further in view of Fisher et al., U.S. Patent 6,203,814 ("*Fisher*"). Office Action at 3.

Applicant respectfully traverses the rejection.

Claims 3 and 4 are dependent upon Claim 1, which claims, *inter alia*, that the carbon nanotubes comprise single-wall carbon nanotubes. As discussed above, *Marchetti* teaches buckyballs, which are round, and much different than single-wall carbon nanotubes having a high aspect ratio. Neither *Marchetti* nor *Fisher* teaches, suggests or provides motivation for single-wall carbon nanotubes. *Fisher* teaches functionalized fibrils, which are also referred to as

buckytubes, graphitic nanotubes, tubular fullerenes and nanofibers. (See *Fisher* at Col. 1, *ll.* 5-7 and *ll.* 52-53.) Fibrils are also quite different than single-wall carbon nanotubes.

The distinction between single-wall carbon nanotubes and fibrils is important because fibrils are fundamentally different from single-wall carbon nanotubes. The structural differences between single wall carbon nanotubes and fibrils cause the materials to have very different properties, as well as significant and unpredictable chemical reactivity and performance differences. Whereas single-wall carbon nanotubes have diameters from about 0.5 nm to about 3 nm, fibrils are much thicker with diameters about 3.5 nm and greater. Whereas single-wall carbon nanotubes are highly flexible, fibrils are quite stiff, rigid and inflexible. Because single-wall carbon nanotubes have only a single layer of generally defect-free sp^2-hybridized carbon atoms, they generally cannot support defects in growth and are more susceptible to destruction by bond breakage or reaction. Fibrils, in contrast, are composed of many, generally cylindrical, concentric carbon layers. Because of this arrangement, the carbon shells of fibrils can withstand wall defects, which often appear as dislocations, kinks, holes, edges on the side-wall surfaces, *etc*. Whereas single-wall carbon nanotubes "rope" and are held tightly together by van der Waals forces, making them difficult to separate and disperse in other media, fibrils, in contrast, do not "rope" together and are readily separable and dispersible. Also, because of their multiple layers and the interconnections between these layers, fibrils can withstand much more rigorous chemical processing (such as those incurred during functionalization and derivatization), physical conditions, and extensive chemical bond breakage without nanotube destruction which can often, and more easily, occur with single-wall carbon nanotubes.

The many structural differences between single-wall and fibrils also result in numerous differences in physical and chemical properties, such as tensile strength, modulus, flexibility,

thermal conductivity, electrical conductivity, chemical reactivity and chemical stability. In turn, the multitude of physical and chemical fundamental differences between single-wall nanotubes and fibrils provide a basis for expecting and obtaining quite different results with single-wall nanotubes versus fibrils in compositions or structures comprising them.

Neither *Marchetti* nor *Fisher* teaches, suggests or provides motivation to modify the reference to include single-wall carbon nanotubes in order to arrive at the elements claimed in Claims 3 or 4. Furthermore, even if the teachings of *Marchetti* and *Fisher* were combined, the combination would not teach or suggest all the limitations of Claims 3 and 4, which also include the elements of amended Claim 1, from which Claims 3 and 4 depend. Thus, Claims 3 and 4 are not *prima facie* obvious.

Therefore, Applicant respectfully requests that the Examiner withdraw the rejection of Claims 3 and 4 under 35 U.S.C. § 103(a) as being unpatentable over *Marchetti* in view of *Fisher*.

4. Rejections Under 35 U.S.C. §103(a) over Marchetti in view of Satoru

The Examiner has rejected Claim 6 under 35 U.S.C. § 103(a) as being unpatentable under 35 U.S.C. § 103(a) over *Marchetti* as applied above, and further in view of Satoru et al., JP 08-031444 ("*Satoru*"). Office Action at 3.

Applicant respectfully traverses the rejection.

Claim 6 is dependent upon Claim 1, as amended, which claims, *inter alia*, that the carbon nanotubes comprise single-wall carbon nanotubes and "wherein the catalyst metal comprises platinum and ruthenium." *Marchetti* teaches buckyballs as the carbon layer and platinum as a catalyst metal. *Marchetti* does not teach, suggest or provide motivation for single-wall carbon nanotubes or the catalyst metal to be a combination of platinum and ruthenium. *Satoru* teaches buckyballs, C_{60}, and fullerenes, such as C_{70} and C_{120}, as carbon supports for the metal catalyst.

Satoru teaches platinum as the catalyst metal. *Satoru* teaches metals that are effective in the dissociative adsorption of hydrogen, as cited below.

> Moreover, as the metal catalyst which acts effective in the dissociative adsorption of hydrogen, use of many metals, such as palladium and nickel, is also possible besides the platinum stated in the example.
>
> (*Satoru* at paragraph 35.)

Thus, *Satoru* teaches other metals that are not necessarily noble metals, such as nickel. Furthermore, *Satoru* does not teach any combination of metals as the catalyst either. *Satoru* does not teach, suggest or provide motivation for single-wall carbon nanotubes or for the catalyst metal comprising a combination of platinum and ruthenium.

Applicant notes the teaching or suggestion to make the claimed combination and the reasonable expectation of success must not be taken from applicant's disclosure. The only way one could arrive at the presently claimed invention would be through the use of hindsight. Hindsight of course is not permissible in § 103 analysis. "One cannot use hindsight reconstruction to pick and choose among isolated disclosures in the prior art to deprecate the claimed invention." *In re Fine*, 837 F.2d 1071, 5 U.S.P.Q.2d 1596, 1600 (Fed. Cir. 1988).

Neither *Marchetti* nor *Satoru* teaches, suggests or provides motivation for single-wall carbon nanotubes or the catalyst metal comprising platinum and ruthenium, as in Claim 6. Furthermore, even if the teachings of *Marchetti* and *Satoru* were combined, the combination would not teach or suggest all the limitations of Claim 6. Thus, Claim 6 is not *prima facie* obvious.

Therefore, Applicant respectfully requests that the Examiner withdraw the rejection of Claim 6 under 35 U.S.C. § 103(a) as being unpatentable over *Marchetti* in view of *Satoru*.

5. Rejections Under 35 U.S.C. §103(a) over Marchetti in view of Hampden-Smith

The Examiner has rejected Claims 7-11 under 35 U.S.C. § 103(a) as being unpatentable under 35 U.S.C. § 103(a) over *Marchetti* as applied to Claim 1, and further in view of Hampden-Smith et al., U.S. Patent Publication 2003/198849 ("*Hampden-Smith*"). Office Action at 4.

Applicant respectfully traverses the rejection.

Claims 7-11 are dependent upon Claim 1, which has been amended to include, *inter alia*, "wherein the carbon nanotubes comprise single-wall carbon nanotubes." *Marchetti* teaches a fullerene carbon layer of buckyballs and does not disclose, teach or suggest single-wall carbon nanotubes. *Hampden-Smith* teaches an electrocatalyst powder having a particle size from about 10-100 nm. The Examiner contends that *Hampden-Smith* discloses "homo- and hetero-fullerene and carbon nanotube based material." (Office Action at 4) However, *Hampden-Smith* does not teach, suggest or provide motivation for single-wall carbon nanotubes. Furthermore, single-wall carbon nanotubes have a smaller diameter, i.e., in the range of about 0.5 nm and about 3 nm, whereas *Hampden-Smith* discloses larger particles in the range of 10-100 nm.

Neither *Marchetti* nor *Hampden-Smith* teaches, suggests or provides motivation for the all the elements claimed in Claims 7-11, which include the elements of amended Claim 1. Even if the teachings of *Marchetti* and *Hampden-Smith* were combined, the combination would not teach or suggest all the limitations of Claims 7-11. Thus, Claims 7-11 are not *prima facie* obvious.

Therefore, Applicant respectfully requests that the Examiner withdraw the rejection of Claims 7-11 under 35 U.S.C. § 103(a) as being unpatentable over *Marchetti* in view of *Hampden-Smith*.

6. Rejections Under 35 U.S.C. §103(a) over Marchetti in view of Hampden-Smith

The Examiner has rejected Claims 13-16 under 35 U.S.C. § 103(a) as being unpatentable under 35 U.S.C. § 103(a) over *Marchetti* as applied to Claim 1, and further in view of *Hampden-Smith*". Office Action at 5.

Applicant respectfully traverses the rejection.

Claims 13-16 are dependent upon Claim 1, which, as amended, includes, *inter alia*, the element of single-wall carbon nanotubes. As discussed above, neither *Marchetti* nor *Hampden-Smith* teaches, suggests or provide motivation for single-wall carbon nanotubes.

Therefore, neither *Marchetti* nor *Hampden-Smith* teaches, suggests or provides motivation for the all the elements claimed in Claims 13-16, which include the elements of amended Claim 1. And, even if the teachings of *Marchetti* and *Hampden-Smith* were combined, the combination would not teach or suggest all the limitations of Claims 13-16. Thus, Claims 13-16 are not *prima facie* obvious.

Therefore, Applicant respectfully requests that the Examiner withdraw the rejection of Claims 13-16 under 35 U.S.C. § 103(a) as being unpatentable over *Marchetti* in view of *Hampden-Smith*.

7. Conclusion

As a result of the foregoing, Applicant asserts that the Claims are now in condition for allowance.

The Examiner is invited to contact the undersigned attorney at (713) 934-4094 with any questions, comments or suggestions relating to the referenced patent application.

Respectfully submitted,

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